
PJM Cost of New Entry

Combustion Turbines and Combined-Cycle Plants
with June 1, 2022 Online Date

PREPARED FOR



PJM Interconnection, L.L.C.

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April 19, 2018

Executive Summary

PJM Interconnection, L.L.C (PJM) retained The Brattle Group (Brattle) and Sargent & Lundy (S&L) to review key elements of the Reliability Pricing Model (RPM), as required periodically under PJM’s tariff.¹ This report presents our estimates of the Cost of New Entry (CONE). A separate, concurrently-released report presents our review of PJM’s methodology for estimating the net energy and ancillary service (E&AS) revenue offset and the Variable Resource Requirement (VRR) curve.²

CONE represents the total annual net revenue (net of variable operating costs) that a new generation resource would need to recover its capital investment and fixed costs, given reasonable expectations about future cost recovery over its economic life. CONE is the starting point for estimating the Net Cost of New Entry (Net CONE). Net CONE represents the first-year revenues that a new resource would need to earn in the capacity market, after netting out E&AS margins from CONE. CONE and Net CONE of the simple-cycle combustion turbine (CT) reference resource are used to set the prices on PJM’s VRR curve.³ CT and combined-cycle (CC) Net CONE are used to establish offer price thresholds below which new gas-fired generation offers are reviewed under the Minimum Offer Price Rule (MOPR).⁴

We estimate CONE for CTs and CCs in each of the four CONE Areas specified in the PJM Tariff, with an assumed online date of June 1, 2022.⁵ Our estimates are based on complete plant designs reflecting the locations, technology choices, and plant configurations that developers are likely to choose, as indicated by actual projects and current environmental requirements. For both the CT and CC plants, we specify GE 7HA turbines—one for the CT, and two for the CC in combination with a single heat recovery steam generator and steam turbine (“2×1 configuration”). Most plants have selective catalytic reduction (SCR), except CTs in the Rest of RTO Area. Most plants also have dual-fuel capability, except CCs in the SWMAAC Area, which obtain firm gas transportation service instead.

For each plant type and location, we conduct a comprehensive, bottom-up analysis of the capital costs to build the plant: the engineering, procurement, and construction (EPC) costs, including equipment, materials, labor, and EPC contracting; and non-EPC owner’s costs, including project

¹ PJM Interconnection, L.L.C. (2017). PJM Open Access Transmission Tariff. Effective October 1, 2017, (“PJM 2017 OATT”), accessed 2/7/2018 from <http://www.pjm.com/directory/merged-tariffs/oatt.pdf>, Section 5.10 a.

² “Fourth Quadrennial Review of PJM’s Variable Resource Requirement Curve” or “2018 VRR Report”.

³ See 2018 VRR Report for how CONE and Net CONE values are used to set the VRR curve.

⁴ PJM 2017 OATT, Section 5.14 h.

⁵ Previous CONE studies had five CONE Areas, but the Dominion CONE Area was removed in recent tariff changes and is now included in the Rest of RTO CONE Area.

development, financing fees, gas and electric interconnection costs, and inventories. We separately estimate annual fixed operation and maintenance (O&M) costs, including labor, materials, property taxes, and insurance.

Finally, we translate the estimated costs into the annualized average net revenues the resource owner would have to earn over an assumed 20-year economic life to achieve its required return on and return of capital. We assume an after-tax weighted-average cost of capital (ATWACC) of 7.5% for a merchant generation investment, which we estimated based on various reference points. An ATWACC of 7.5% is equivalent to a return on equity of 12.8%, a 6.5% cost of debt, and a 65/35 debt-to-equity capital structure with an effective combined state and federal tax rate of 29.25%. For some states with higher state income tax rates of 10%, the ATWACC is 7.4%. We adopt the “level-nominal” approach for calculating the first-year annualized costs of the plants.

Table ES-1 below shows the updated 2022/23 CONE estimates and how the values compare to the CONE parameters used in the upcoming auctions for the 2021/22 delivery year, escalated forward one year to 2022/23. As indicated, costs have decreased sharply by 22–28% for CTs and 40–41% for CCs.

Table ES-1: Updated 2022/2023 CONE Values

	Simple Cycle (\$/ICAP MW-year)				Combined Cycle (\$/ICAP MW-year)			
	EMAAC	SWMAAC	Rest of RTO	WMAAC	EMAAC	SWMAAC	Rest of RTO	WMAAC
2021/22 Auction Parameter	\$133,144	\$140,953	\$133,016	\$134,124	\$186,807	\$193,562	\$178,958	\$185,418
...Escalated to 2022/23	\$136,900	\$144,900	\$136,700	\$137,900	\$192,000	\$199,000	\$184,000	\$190,600
Updated 2022/23 CONE	\$106,400	\$108,400	\$98,200	\$103,800	\$116,000	\$120,200	\$109,800	\$111,800
Difference from Prior CONE	-22%	-25%	-28%	-25%	-40%	-40%	-40%	-41%

Sources and notes:

All monetary values are presented in nominal dollars.

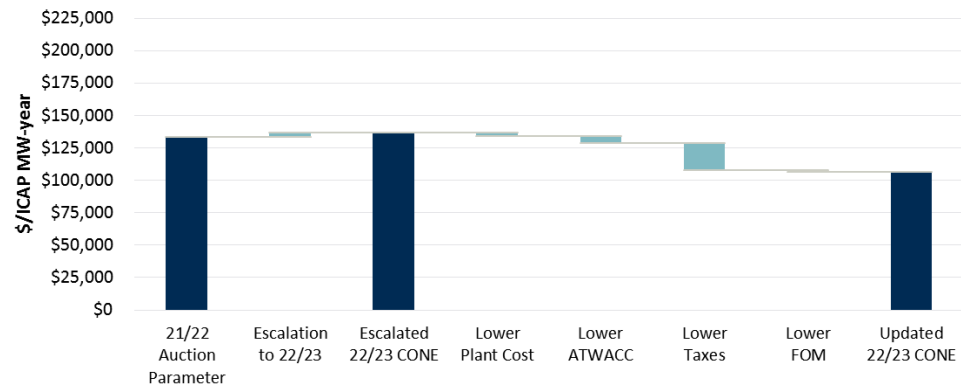
2021/22 auction parameter values based on Minimum Offer Price Rule (MOPR) Floor Offer Prices for 2021/22 BRA.

PJM 2021/22 parameters escalated to 2022/23 by 2.8%, based on S&L analysis of escalation rates for materials, turbine, and labor costs.

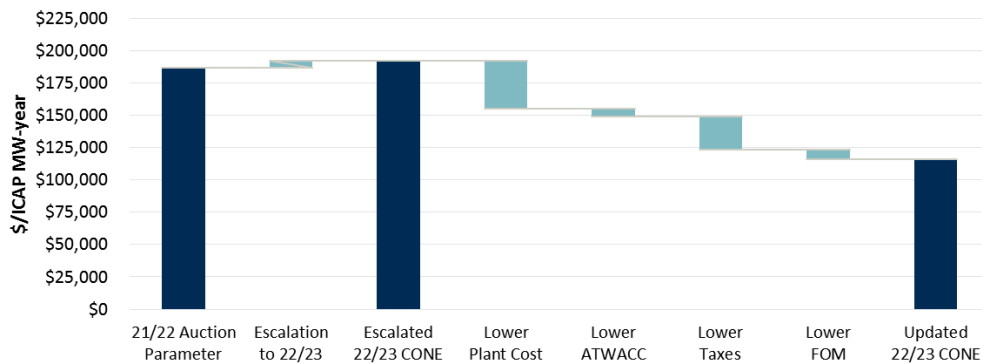
CONE includes major maintenance costs in variable O&M costs. Alternative values with major maintenance costs in fixed O&M costs are presented in Appendix C.

The drivers of these decreases are shown in Figure ES-1 and explained below.

Figure ES-1: Drivers of Lower CT and CC 2022/2023 CONE Estimates (EMAAC)
 (a) Simple Cycle Combustion Turbine (CT)



(b) Combined Cycle (CC)



Notes:

“FOM” stands for fixed O&M costs.

CONE includes major maintenance in variable O&M costs.

Three factors drive most of this decrease in CONE:

- **Economies of scale on larger combustion turbines.** Selection of GE 7HA.02 turbines instead of the 7FA.05 turbines used in the 2014 PJM CONE study reflects a recent trend in actual project developments and future orders toward larger turbines. The GE H-class turbines are sized at 320 MW per turbine compared to 190 MW for F-class turbines in 2014; the capacity of a 2×1 CC plant nearly doubles from 650 to 1,140 MW.⁶ This lowers both construction labor and equipment costs on a per-kW basis. As a result, the current overnight capital costs for a CT are only \$799/kW to \$898/kW (depending on location), 2–10% lower than the 2014 estimates of \$890/kW to \$927/kW escalated forward to 2022.⁷

⁶ The max summer capacity is based on the estimated values for the Rest of RTO CONE Area.

⁷ We compare the current capital cost estimates to those filed by PJM in the 2014 CONE update. We escalated the 2018 capital costs to 2022 by first applying the location-specific escalation rates PJM used for the 2019/20, 2020/21, and 2021/22 CONE updates for the first three years and then escalating the costs an additional year by 2.8%/year based on cost trends in labor, equipment, and materials inputs.

CC capital costs range from \$772/kW to \$873/kW, about 25% lower than the 2014 estimates of \$1,054/kW to \$1,127/kW escalated to 2022.

- **Reduced federal taxes.** The tax law passed in December 2017 reduced the corporate tax rate to 21% and temporarily increased bonus depreciation to 100%, although it eliminated the state income tax deduction.⁸ These changes decrease the CT CONE by about \$21,000/MW-year (17% lower) and the CC CONE by about \$25,000/MW-year (18% lower), before accounting for the higher cost of capital due to the lower tax rate.
- **Lower cost of capital.** We estimate an ATWACC of 7.5% for merchant generation based on current and projected capital market conditions and the change in the corporate tax rate. Compared to an ATWACC of 8.0% in the 2014 study, the lower ATWACC reduces the annual CONE value by 3.7% for CTs and 3.8% CCs.

The updated CONE values shown above assume that major maintenance costs are treated as variable O&M costs, as in past CONE studies. We separately report in Appendix C alternative CONE values to reflect changes in the PJM cost guidelines since the 2014 CONE Study in which major maintenance costs are classified as fixed O&M costs instead of variable O&M costs.⁹ Classifying these costs as fixed instead of variable increases CONE by \$19,000/MW-year for CTs (a 19% increase) and \$10,000/MW-year for CCs (a 9% increase). However, removing these costs from variable O&M increases Net E&AS revenues and offsets the increased CONE value in the calculation of Net CONE.

Table ES-2 shows additional details on the CONE estimates for CT plants in each CONE Area. The higher CONE in SWMAAC relative to other areas reflects higher property taxes in Maryland that are based on all property, including equipment, not just land and buildings. EMAAC's relatively high costs reflect higher labor costs there. The Rest of RTO Area has the lowest CONE value due to lower labor costs and the assumption that an SCR is not needed to reduce NOx emissions in attainment areas.

⁸ "Bonus depreciation" refers to the allowance by tax law of highly accelerated tax depreciation immediately upon in-service of a depreciable asset. In recent years, bonus depreciation has been enabled by legislation in varying percentages of the overall tax basis in an asset, with the remainder deducted over the asset life as otherwise allowed. Per the 2017 tax law, bonus depreciation is allowed for companies not classified as public utilities up to 100% of tax basis.

⁹ An ongoing stakeholder process within the Markets Implementation Committee is addressing whether the PJM cost guidelines should be modified to again allow major maintenance costs to be included in variable O&M costs.

Table ES-2: Estimated CT CONE for 2022/2023

		Simple Cycle			
		EMAAC	SWMAAC	Rest of RTO	WMAAC
Net Summer ICAP	<i>MW</i>	352	355	321	344
Overnight Costs	<i>\$/kW</i>	\$898	\$836	\$799	\$886
Effective Charge Rate	<i>%</i>	10.1%	10.1%	10.0%	10.0%
Plant Costs	<i>\$/MW-yr</i>	\$90,300	\$84,300	\$80,300	\$88,900
Fixed O&M	<i>\$/MW-yr</i>	\$16,100	\$24,100	\$17,900	\$14,900
Levelized CONE	<i>\$/MW-yr</i>	\$106,400	\$108,400	\$98,200	\$103,800
Levelized CONE	<i>\$/MW-day</i>	\$292	\$297	\$269	\$284

Notes: CONE values expressed in 2022 dollars and Installed Capacity (ICAP) terms.

Table ES-3 shows the recommended CONE estimates for CC plants in each CONE Area. SWMAAC has the highest CONE estimate due to higher property taxes and the higher costs of firm gas transportation service compared to dual-fuel capabilities (which is specified in the other Areas). EMAAC has the next highest CONE estimate due to higher labor costs than the rest of PJM. WMAAC and Rest of RTO have the lowest CC CONE estimates due to the lower labor costs in those areas.

Table ES-3: Estimated CC CONE for 2022/2023

		Combined Cycle			
		EMAAC	SWMAAC	Rest of RTO	WMAAC
Net Summer ICAP	<i>MW</i>	1,152	1,160	1,138	1,126
Overnight Costs	<i>\$/kW</i>	\$873	\$772	\$815	\$853
Effective Charge Rate	<i>%</i>	10.6%	10.6%	10.5%	10.5%
Plant Costs	<i>\$/MW-yr</i>	\$92,200	\$81,800	\$85,900	\$89,900
Fixed O&M	<i>\$/MW-yr</i>	\$23,800	\$38,400	\$23,900	\$21,900
Levelized CONE	<i>\$/MW-yr</i>	\$116,000	\$120,200	\$109,800	\$111,800
Levelized CONE	<i>\$/MW-day</i>	\$318	\$329	\$301	\$306

Notes: CONE values expressed in 2022 dollars and ICAP terms.

The updated CONE estimates for CCs have decreased significantly more than CTs over the prior estimates, leading to a CC premium of \$8,000–11,800/MW-year compared to \$46,000–54,000/MW-year in the 2020/21 Base Residual Auction (BRA) parameters. The most significant driver narrowing the difference between CT and CC CONE is economies of scale of the larger CC based on the 7HA. While the capacity of the CCs plants has almost *doubled* compared to that in the 2014 CONE Study, the cost of the gas turbines increased by 50%, and the cost of the steam section of the CC (including the heat recovery steam generator and steam turbine) increased by only 30%. CT plants share the same economies of scale on the combustion turbine itself, but not the greater economies of scale that CCs enjoy on their steam section or other plant costs.

Looking beyond the 2022/23 delivery year, we recommend that PJM update the above CONE estimates prior to each subsequent auction using its existing annual updating approach based on a composite of cost indices, but with slight adjustments to the weightings. Consistent with the updated capital cost estimates, we recommend that PJM weight the components in the CT composite index based on 20% labor, 55% materials (increased from 50%), and 25% turbine (decreased from 30%). We recommend that PJM weight the CC components based on 30% labor (increased from 25%), 50% materials (decreased from 60%), and 20% turbine (increased from 15%). PJM will need to account for bonus depreciation declining by 20% in subsequent years starting in 2023. Consequently, after PJM has escalated CONE by the composite cost index, we recommend that PJM apply an additional gross-up of 1.022 for CT and 1.025 for CCs each year to account for the declining tax advantages as bonus depreciation phases out.